J. Indian Water Resour. Soc.,
Vol 37, No. 1, Jan, 2017 (Special Issue)

A LOW COST DRIP IRRIGATION SYSTEM FOR ADOPTION IN JHUM CULTIVATION AREAS IN NAGALAND FOR FOOD SECURITY

Arnab Sarma
Head, Department of Civil Engineering
Royal School of Engineering & Technology
Betkuchi, Guwahati-781035
Email: arnab.sarma@rgi.edu.in

ABSTRACT

Nagaland is a small hill state situated in the northeastern region of India, which is bounded by the state of Assam in the west, Manipur in the south, Arunachal Pradesh and parts of Assam on the north and Myanmar on the east. It lies between 25º 6' and 27º 4' northern latitude and 93º 20' and 95º 15' eastern longitude. The state has a geographical area of 16,579 sq. km. constituting barely 0.5% of India's total geographical area and a population of about 20 lakh representing only 0.2% of the country's population (Government of India 2011). The state is predominantly rural and 82.26% of its population lives in villages with strong dependence on natural resources (Government of Nagaland 2012). The Nagas, the people of Nagaland are a group of indigenous people recognized as a 'tribal group' under the Constitution of India. The Nagas by being people of the hills have always depended on the natural environment for sustenance, survival and livelihood. Availability of arable land being limited in most of the districts, the dynamics of people-land relationship is of vital importance for the people of the state. Almost 90% of the land in Nagaland is under private or community ownership including fallow forests and shifting cultivation areas. Shifting cultivation or jhum, as it is widely referred to in the region, is the most common land-use practice across Nagaland. Shifting (jhum) cultivation is an integral part of the Naga people and their socio-cultural life is closely linked to it as most of the social festivals and ceremonies are rooted in the shifting cultivation cycle.

In order to wean away shifting cultivators from the practice, the government introduced numerous cash crop plantation programmes, as well as permanent land-use alternatives, but most of them did not succeed. In the process, shifting cultivation was completely ignored and farmers rarely received any support from government agencies for improving shifting cultivation. As a result, shifting cultivation continues to be widely practiced by farmers as this is perhaps the most suitable system adopted in response to the natural environment and physiographic condition of the region. One of the biggest external factors that negatively influenced shifting cultivators was unsupportive central government policy, which often referred to shifting cultivation as unproductive, primitive, unsustainable and destructive to the environment. Such misconceptions by policy-makers and planners meant that there were no direct initiatives contributing to the development of shifting cultivation as a practice. Rather all interventions on shifting cultivators were aimed at eradicating the practice without providing a substitute system that is sustainable. This is not to say that Jhum cultivation in its present form is sustainable. On the contrary, the practice is faced severe constraints due mainly to population growth and intensification of the Jhum cycle. In light of the above, it is now time that we make Jhum cultivation productive and sustainable. An essential step towards this goal would be assured supply of irrigation to increase productivity leading to food security of hill farmers of Nagaland. In this context, a low cost drip irrigation system is suggested for adoption in Jhum cultivation areas after sufficient number of field trials.

INTRODUCTION

Nagaland is a small hill state situated in the northeastern region of India bounded by Assam in the west, Manipur in the south, Arunachal Pradesh and parts of Assam on the north and Myanmar on the east. It lies between 25º6′ and 27º4′ N latitude and 93º20′ and 95º15′ E longitude. The geographical area of the state is 16,579 sq. km. constituting barely 0.5% of India's total area and a population of about 20 lakh representing 0.2% of the country's population (GoI 2011). The state is predominantly rural and 82.26% of its population lives in villages with strong dependence on natural resources (Govt. of Nagaland 2012).

The Nagas, the people of Nagaland are a group of indigenous people recognized as a 'tribal group' under the Constitution of India. The Nagas by being people of the hills have always depended on the natural environment for sustenance, survival and livelihood. Availability of arable land being limited in most of the districts, the dynamics of people-land relationship is of vital importance for the people of the state. Almost 90% of the land in Nagaland is under private or community ownership including fallow forests and shifting cultivation areas.

Fig. 1: The state of Nagaland

Shifting cultivation or jhum, is the most common land-use practice across Nagaland. It is an integral part of the Naga people and their socio-cultural life is closely linked to it as most of the social festivals and ceremonies are rooted in the shifting cultivation cycle. Despite various initiatives by the government to wean the farmers away from Jhum cultivation, it continues to be widely practiced by the hill farmers of

Nagaland as this is perhaps the most suitable system adopted in response to the natural environment and physiographic condition of the state. It is a traditional, low external input-based, zero-tillage cultivation system. Jhum plots are selected based on the traditional knowledge of the jhumias (shifting cultivators) who still consider the jhum system as one of the best livelihood options to ensure food security because rice, different vegetables and cash crops are available from jhum and fallow jhum fields to meet their requirements.

Fig. 2: Typical Jhum field

However, any system proposed would have to be economically viable meaning that the farmers must be able to afford and also be easy to operate to be acceptable to them. This warrants certain modifications would be required in terms of land manipulation by way of construction of terraces, wherever required. Additionally, water harvesting as well as water diversion headworks would also be necessary to source adequate quantity of water.

A closer look at the systems being practiced reveal that four types of jhum-based livelihood systems can be found in Nagaland at present viz. (i) Jhum only, (ii) Mainly cash crop cultivation along with usual jhum crops, (iii) Mixed farming system with both jhum system and limited plain land agriculture that includes cultivation of fruit and timber trees and (iv) Sequential conversion of jhum to horticultural cropping. The last of the four systems mentioned has the highest potential in terms of economic sustainability.

Jhum being a rain dependent system, the productivity is low due mainly to non-availability of timely irrigation. Though it has not been well-researched whether Drip irrigation can really supplement the system to achieve higher productivity, there is scope and also need that necessary steps be initiated. Water being scarce in the hills, it is hoped that a system with minimum water losses and minimum labour would be useful.

However, any system proposed would have to be economically viable meaning that the farmers must be able to afford and also be easy to operate to be acceptable to them. This warrants certain modifications would be required in terms of land manipulation by way of construction of terraces, wherever required. Additionally, water harvesting as well as water diversion headworks would also be necessary to source adequate quantity of water.

TRADITIONAL DRIP SYSTEM

Not many people are probably aware that there has existed a traditional drip called the "bamboo drip system" in the north-eastern state of Meghalaya for more than 200 years. The farmers of Jaintia and Khasi of the state have been using this indigenous technique to irrigate their plantation crops by tapping springs and stream water to grow betal leaves, black pepper and arecanut with excellent success rate. Small holes are made at the internodes of open bamboo channels, from where water gets trickled down in the field as shown below. These channels are placed along the natural gradients. However, no uniform head for water trickling is maintained here.

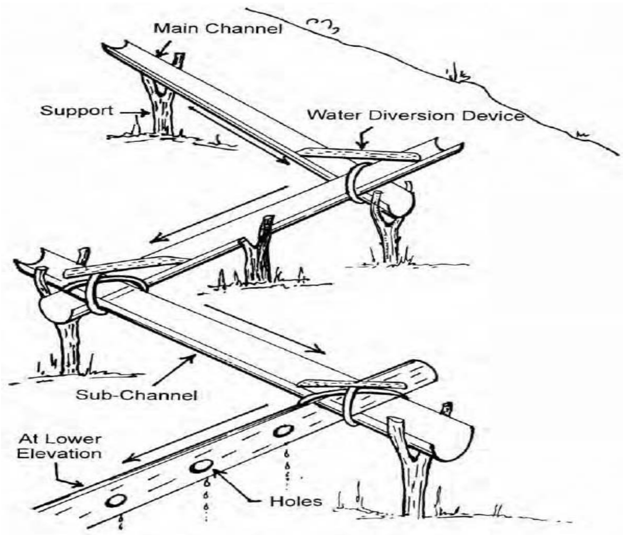

Fig. 3: Sketch of bamboo drip system

As shown above (Fig. 3), these bamboo networks usually have 4-5 diversion stages before water is delivered at the base of the plant. It is roughly estimated that about 18-20 liters per minute of water from the main channel gets reduced to about 10-80 drops per minute at end of the network (Fig. 4).

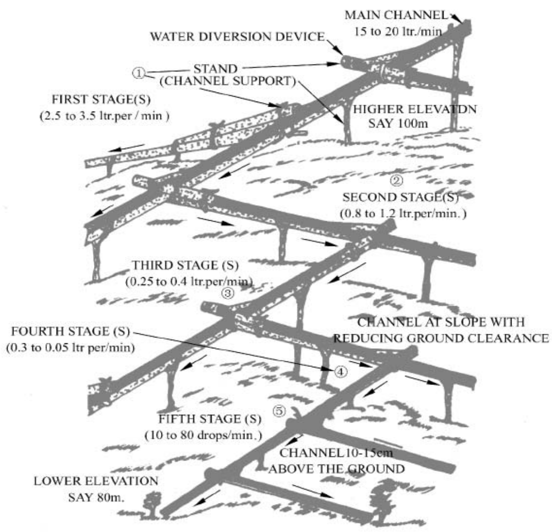

Fig. 4: Water distribution in bamboo drip system

After this long journey, the water trickles or drips drop by drop at the base of the plant. Sometimes water is diverted to distant houses for domestic use. It is understandable that there is considerable loss of water at each of the water diversion devices due to spills and also through the open ends of the main as well as the sub-channels. Nevertheless, the system is well-adopted to local conditions if not as a water saving method but as a easy to use sustainable method.

PRESENT STATUS OF DRIP IN NAGALAND

It is not very well documented as to the extent of area that has so far been brought under drip system of irrigation in the state of Nagaland. However, a rough estimate on area brought under Micro Irrigation Systems over the years may be found in relevant literature (Kumar M. D. et al 2008). The same is presented below.

Year	**2001-02**	**2002-03**	**2003-04**	**2004-05**
Area (ha)	60	55	100	50

Needless to mention, the area figures presented above, in most likelihood pertain to flat areas where conventional drip systems would work with a fair degree of efficiency in terms of distribution and emission. The same system (s) however, would fail in slopped areas owing mainly to the above issues.

THE PROPOSED SYSTEM

Any system proposed for Nagaland in general and the Jhum cultivation areas in specific would have to take advantage of the topography i.e. the gravitational head would be used to operate the system. This would eliminate the initial and operational cost of pumping thereby moving a step forward to becoming economically viable for the farmers. In other words the system would be Low-Cost. It is known that most of the available long path turbulent flow emitters require an operating water pressure head of 10 m or more for optimum performance. In addition, pressure head is also required to take care of the friction losses in the system. As such, these systems would not work properly in our case due to the fact that the elevation difference between two adjacent terraces ranges between 0.5 and 5.0 m. This pressure would be insufficient to operate the system using turbulent flow emitters. Thus, an alternative arrangement is needed.

Bhatnagar et al. (1998) obtained low emission uniformity (64–72%) for emitters operating at pressure head of 4.0–6.5 m. However, emission uniformity increased to 94–98% on replacing the emitters with micro-tubes (1.0 mm □) for the same conditions. Another problem encountered could be the variation in emitter discharge, if the system is laid on several terraces (depending on crop type) having varying elevations, sizes, slopes and shapes. These issues along with 'what can be done' to make a system acceptable to farmers are discussed below.

THE ISSUE OF PHYSICAL EFFICIENCY

Although the proposition of having a low cost drip irrigation system appears to be attractive, the system may have low physical efficiency when used for crops with small plant spacing viz. chilly, vegetables and potato. To use the system for these crops and derive intended benefit, it is very important that the farmers maintain fixed row as well as plant spacing (row-to-row and plant-to-plant). So far as maintaining the spacing between rows is concerned, farmers pay sufficient attention. But, spacing between plants is not observed because of being oblivious of the increased benefits that can be derived in terms of plant health. Due to this planting practice, designing and installing drippers becomes. Therefore, the farmers' agricultural practices need new approaches. It is in this context that a study is being conducted at the Royal School of Engineering & Technology under the Assam Science and Technology University, Guwahati, Assam, India in collaboration with an NGO in Nagaland.

Achieving irrigation uniformity

Drip can potentially improve irrigation uniformity, but on steep fields, achieving a high uniformity can be challenging. An elevation change of 2.3 feet may cause a 1 pound per square inch (psi) change in pressure in a drip line. Drip tape on a 5% sloped field, would have a change in pressure of about 6 psi along a 300 feet distance. Assuming the drip tape was medium flow tape (0.32 gpm/100 ft), and the pressure at the manifold was 10 psi, then 25% more water would be applied at the lower end of the field compared to the top of the slope. The result would be that the extra water applied at the lower end of the field may saturate the soil fully, which may promote soil borne root diseases, as well as increase the amount of fertilizer applied through the drip system. Because the terrain of each Jhum pocket is unique, different solutions must be used to improve drip uniformity. This warrants designing the most economical system to manage slope effects on irrigation uniformity. A discussion on this aspect is presented in the following section to increase drip uniformity if elevation varies among irrigation blocks, along the length of the beds, or along the latearals/manifold/sub-main.

A simple solution is to adjust the pressure using a gate valve. An accurate pressure gauge could also be used to check the pressure of the lateral periodically in case the upstream pressure changes. A preferable remedy is to add a pressure regulator after the gate valve. This would entail cost. It is to be kept in mind that pressure regulators can only reduce pressure on the downstream side, so the upstream pressure must be maintained above the desired downstream pressure. The system being Low-Cost plastic pressure regulators may be used instead of steel and brass regulators.

Managing elevation change

In a slopped land such as jhum land, the water pressure of the mainline will vary among irrigation blocks located at different elevations relative to the water source. If the block is below the water source (obvious in slopped land), then pressure in the mainline may be high. In this case the blocks are to be adjusted to the same pressure in order to apply water uniformly and solutions to this effect are available.

Managing slope along the bed

A slope of 2% or less is the ideal for drip irrigation. Orienting beds with the contours of the slope can minimize elevation changes along the bed. Elevation changes should be less than 2%, which equates to a pressure difference of about 2.6 psi between the beginning and the end of the bed of 300'. The following aspects might need consideration.

- Locating the lateral at the low end of the beds is not recommended because the frictional loss would add to the pressure loss due to increase in elevation.
- Shortening the length of the beds can also minimize the elevation change along the beds, but may be costly as extra hardware would be needed.

Increasing the operating pressure can minimize the elevation effects on uniformity because the variation in pressure becomes less relative to the average pressure. However, this may require use of thick walled tape/pipe to prevent bursting of the tape thereby adding to system costs.

Managing slope along the lateral/submain

Even with beds oriented along the contours of the terrain, elevation change along the submain (if used) can cause pressure to vary between beds at the top and the bottom of a slope. Beds of a similar elevation can be grouped together so that they all have the same pressure. Narrow polyethylene tubing (spaghetti tubing) may also be used to increase the frictional loss of pressure between the lateral and the drip tape. As the pressure in the lateral increases towards the bottom of the slope, narrower and/or longer polyethylene tubes are used to connect the lateral to drip tape in order to bleed off pressure. The length of the polyethylene tube and the narrow diameter causes pressure loss as the water flows into the drip line.

Pressure compensating (PC) tape can also be used to manage elevation changes along the lateral if needed. The same considerations as discussed above should be made in choosing an appropriate PC tape for elevation changes along the laterals.

Reducing drainage water on slopes

When drip systems are placed on sloped ground the common problem (after the irrigation ends) is that the remaining water in the submain and drip lines drains to the low end of the field, saturating the soil. If the slope of the field is oriented along the beds, then adding flush valves to the end of the drip lines can release trapped water. A low pressure release valve can also be used to release water trapped in the low end of the submain/lateral. The outlet of the low pressure release valve can be fitted with a hose so that water can be drained away from the field into a retention basin, if possible.

DESCRIPTION OF THE PROPOSED SYSTEM

As is usual for any drip system to operate efficiently, certain basic components are required. The proposed system would accordingly have the following components.

(i) Water diversion system: This is shown below schematically. Actual design dimensions will have to be worked depending on location and field conditions.

(ii) Water tank: Of suitable dimension depending on field requirement and condition (placed 1 m & above ground level) for smaller systems up to 400 m^2 area.

(iii) Control valve: To regulate pressure and flow of water into the system.

(iv) Filter: For clean water to enter into the system

(v) Mainline: 50 mm PVC (Poly vinyl chloride) or PE (Polyethylene) pipe to convey water

(vi) Sub-main: PVC/PE pipe (not shown in Figure) to supply water to the laterals that are connected to the sub-main at regular intervals.

(vii) Lateral: PE pipes along the rows of the crops on which emitters are connected directly. The size (diameter) of pipe may be 12–16 mm.

(vii) Emitters/micro-tubes: Device through which water is emitted at the root zone of the plant with required discharge.

Farmers can be taught to make pin holes in the plastic tube for water to pass. Space between emitters is variable (between plants, within and between rows). Usually one emitter for each plant is to be provided. Depending on the flow rate of water different sizes of valves, mainlines etc can be used. Additional components include joints/connectors and pegs (used to hold the lateral and micro-pipes in place).

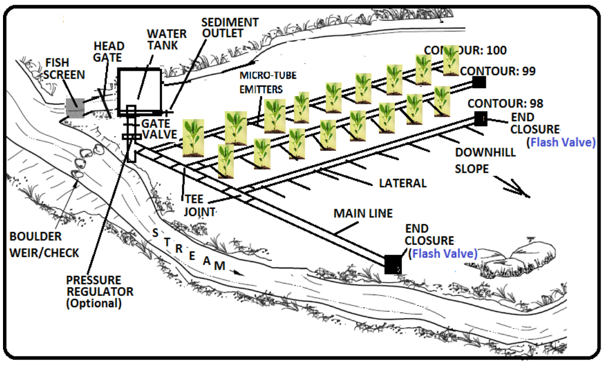

Fig. 5: Schematic layout of the proposed system

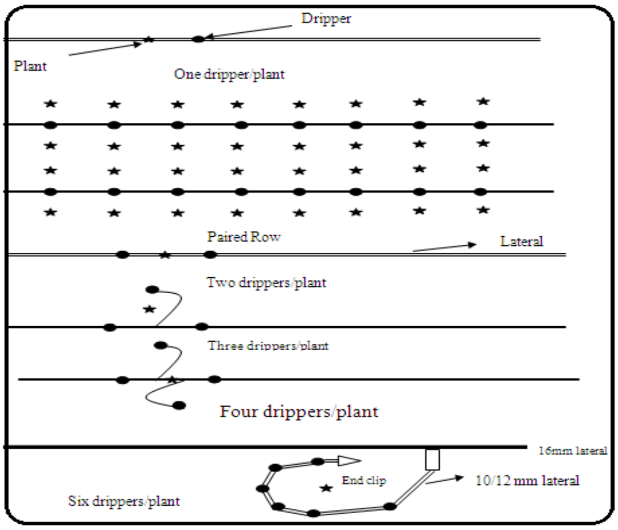

Fig. 6: Various arrangement of emitters along lateral

PRESCRIBED CARE FOR WATER SOURCE

The emitters in a drip system have small diameters that can easily become clogged. Organic materials, such as plant materials, algae, small living organisms and inorganic sand, silt, and clay are of concern if the source of water is from surface water such as a pond or stream. Surface water might have contaminants from runoff too. In the proposed system therefore, a stilling basin kind of an arrangement is to be made use of just after diversion of the water from stream. In case of water sourced from the water harvesting structure, a low cost locally developed filtration is to be used.

SUMMARY

Designing and laying a low-cost drip irrigation system systems for operation on hilly tracts of Nagaland can be challenging and the options for attaining good uniformity would to a large extent depend on the terrain, proper adoption and use by farmers and other unforeseen factors. To make the system technically feasible, new types of components are available, such as pressure compensating tape, inexpensive pressure regulators, and flush valves, that can be used to improve uniformity. With the help of an irrigation designer (field agricultural engineer), one should be able to find an economical solution to attain good irrigation uniformity on hilly land using drip.

The cost-benefit analysis for the system is yet to be done as the price of the component parts of the system in the various markets of Nagaland are not fully known. Moreover, the field trial of the system is pending. Thus, it would be early and immature at this stage to firm up any opinion on that. Even if the system is found to be technically feasible and economically viable, the main problem anticipated at this stage is adoption by the local farmers in general and the shifting cultivators in specific. However, with the extension machinery of the Govt. of Nagaland these hurdles could be overcome.

REFERENCES

1. *Bhatnagar P.R., Srivastava R.C., Bhatnagar V.K. and Ved Prakash (1998). Gravity fed drip irrigation system for cauliflower production in mid-hills of Himalayas. In: Singh R, Kundu DK, James BK, Verma HN (eds) Progress in micro-irrigation research and development in India. WTCER, Bhubaneswar, India, pp 115– 121.*

2. *Department of Statistics (2012). Statistical Handbook of Nagaland- 2012.*

3. *Ella V. B. (2007). A Low-Cost Drip Irrigation System for Small Farms. Land and Water Resources Division, Institute of Agricultural Engineering College of Engineering and Agro-industrial Technology, University of the Philippines Los Banos College, Laguna, PHILIPPINES*

4. *Hunter G. R. (2012). Drip Irrigation Design & Installation Guide. www.hunterindustries.com*

5. *Keller J. and Keller A. A. (2002). affordable Drip Irrigation for Small Farms in Developing Countries*

6. *Kumar M.D. (2008). Water Saving and Yield Enhancing Micro Irrigation Technologies in India: When and where can they become best bet technologies? www.researchgate.net/publication/228894953*

7. *Kumar M. D. (2016). Water Saving and Yield Enhancing Micro Irrigation Technologies in India: Theory and Practice. In: Viswanathan P.K. et al (2016). Micro Irrigation Systems in India- Emergence, Status and Impact, Springer. Vol-XIV,178*

8. *Polka P. et al (1997). A low cost drip irrigation system for small farmers in developing countries, journal of the American Water Resources Association, Vol. 33, No. 1*